2001 P08772

39

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 555 851 A2**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **93102158.8**

(51) Int. Cl.⁵: **F02P 3/04**

(22) Date of filing: **11.02.93**

(30) Priority: **13.02.92 IT BO920049**

(43) Date of publication of application: **18.08.93 Bulletin 93/33**

(84) Designated Contracting States: **DE ES FR GB**

(71) Applicant: **WEBER S.r.l.**
Corso Marconi, 20
I-10125 Torino(IT)

(72) Inventor: **Rossi, Daniele**
Via Vicenza, 1/1
40050 Monte S. Pietro(IT)
Inventor: **Facciolo, Fabio**
Via Filippo Turati, 23
40012 Calderara di Reno(IT)

(74) Representative: **Jorio, Paolo et al**
Studio Torta, Via Viotti, 9
I-10121 Torino (IT)

(54) Ignition control device for an internal combustion engine electronic ignition system.

(57) A device for controlling an electronic engine ignition system (2) comprising a coil (3), the primary winding (4) of which is connected between a reference voltage and ground via a switch block (5), and the secondary binding (6) of which is connected between the electrode of a spark plug (7) and ground. The device comprises means for detecting, for the spark of each operating cycle, signals relative to the energy at the spark plug; means for computing engine speed; means for comparing the energy of the plug with optimum values for each engine speed; and means for controlling charging of the primary winding via a signal resulting from the above comparison, and for driving the switch block, so as to control energy supply to the plug for the spark of the next cycle.

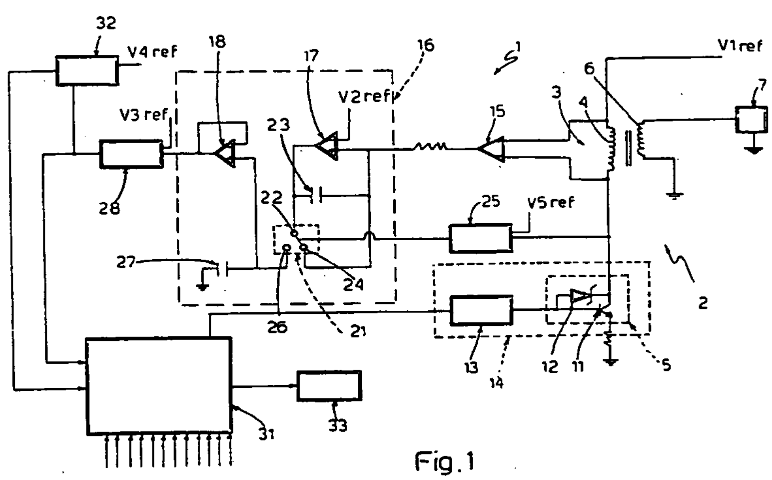


Fig.1

EP 0 555 851 A2

The present invention relates to an ignition control device for an internal combustion engine electronic ignition system.

Pollution control standards are now being issued practically worldwide for controlling all the factors responsible for the pollutants produced by internal combustion engines. The most effective solution for conforming with these standards is to equip the vehicle with electronic injection and ignition systems in conjunction with a catalytic muffler. In view of the high cost of the materials used in the manufacture of catalytic mufflers, however, these must be safeguarded by ensuring optimum operation of the electronic injection and ignition systems. The most widely used electronic ignition systems are inductive discharge types wherein energy stored in the primary winding of the coil is transmitted by a switch device to the secondary winding connected to the spark plug electrodes. Allowing for conversion losses, the energy at the terminals of the secondary winding equals that stored in the primary. As the maximum charge current of the primary winding is constant, and the energy stored in the primary winding is a function of the square of the maximum current, the energy stored in the primary winding and available in the secondary are also constant, so that maximum energy is supplied by the ignition system to the spark plug at all times and at any engine speed, even when the energy required may be less than maximum. Consequently, the ignition system and all the component parts (coil, plugs and electronic components) must be designed to operate continuously at maximum power. In addition to high energy consumption and the high cost of oversizing the components, currently used electronic ignition systems are also subject to severe wear of the component parts, which in turn impairs operation of the system as a whole, thus jeopardizing the catalytic muffler.

It is an object of the present invention to provide an ignition control device for an internal combustion engine electronic ignition system, designed to overcome the aforementioned drawbacks, i.e. which provides for optimizing the energy available in the secondary winding as a function of engine speed.

Further aims and advantages of the present invention will be disclosed in the following description.

According to the present invention, there is provided an ignition control device for an internal combustion engine electronic ignition system; said system comprising a coil, the primary winding of which presents a first terminal connected to a first reference voltage, and a second terminal connected to a reference ground via a switch device, and the secondary winding of which supplies an ignition block; characterized by the fact that it comprises:

means, which, for the spark of each operating cycle of said ignition block, provides for detecting first signals relative to the energy available between the electrodes of said ignition block;

means for processing said first signals and computing a quantity representing the energy available between the electrodes of said ignition block;

means for computing the speed of said engine as a function of a number of second signals;

means for comparing said quantity with values considered optimum for each speed of said engine and stored in an internal memory block; and

means for controlling the charge of said primary winding via a third signal resulting from said comparison, and for driving said switch device, so as to automatically control the energy to be made available between the electrodes of said ignition block for the spark of the cycle following that in which said first signals are detected.

Two preferred, non-limiting embodiments of the present invention will be described by way of example with reference to the accompanying drawings, in which:

Fig.s 1 and 2 show electric diagrams of two embodiments of an ignition control device for an internal combustion engine electronic ignition system.

Number 1 in Fig.1 indicates an ignition control device for the electronic ignition system 2 of an internal combustion engine. System 2 comprises a coil 3, the primary winding 4 of which presents a first terminal connected to reference voltage V1ref (normally equal to the battery voltage), and a second terminal connected to a reference ground via a known transistorized switch device 5. Coil 3 also presents a secondary winding 6 having a first terminal connected to a block 7 (representing one or more spark plugs and, in the latter case, also an ignition distributor), and a second terminal connected to a reference ground. Alternatively, the terminals of secondary winding 6 may be connected to the electrode of a respective plug.

If one of two neighbouring windings is supplied with variable current, current is induced in the other due to variation of the flux linkage. This phenomenon is further enhanced if the two windings are wound about the same magnetic core, thus enabling low-voltage energy to be converted into high-voltage energy, and the production of violent discharges in the form of sparks between the plug electrodes. If primary winding 4 is supplied with direct current, the core is magnetized and primary winding 4 stores energy $E1 = \frac{1}{2} \cdot L1 \cdot I1^2$, where L1 is the primary winding inductance, and I1 the electric current through the primary winding. If I1 is then cut off suddenly, the voltage at the terminals of secondary winding 6 rises so sharply as to produce a violent discharge b tween the plug electrodes,

and the terminals of secondary winding 6 present energy $E2 = \int_{ds} Vm2 \cdot I2pk \cdot dt$, where ds is the duration of the arc produced between the plug electrodes, Vm2 the hold voltage for maintaining the arc, and I2pk the instantaneous arc current.

As shown, the output energy of coil 3 is expressed as the integral of the product of the hold voltage and the arc current within the duration of the arc. Analysis of variations in the above quantities as a function of various operating conditions of the engine has shown that the voltage required between the plug electrodes is determined by engine load and the gap between the plug electrodes, and increases proportionally alongside an increase in hold voltage and a reduction in the duration of the arc, which phenomena are accentuated alongside an increase in engine load. As the duration of the arc is decisive in terms of effective fuel combustion and, consequently, pollutant discharge at certain engine speeds, direct or indirect detection of the duration of the arc may thus be employed as a basis for diagnosing correct operation of ignition system 2 and particularly system components such as the spark plug. Such detection may also be employed for driving switch device 5 and so controlling current I1 in primary winding 4, for enabling system 2 to adapt automatically to the optimum energy value actually required by the engine.

In view of the above, the duration of the arc is deducible from the voltage at the terminals of secondary winding 6, the current of secondary winding 6, and the voltage at the terminals of primary winding 4; and the voltage detected at the terminals of primary winding 4 is used by device 1 for measuring the duration of the arc. In other words, in view of the relationship between the voltage at the terminals of primary winding 4 and the duration of the arc, the latter may be correlated with the current of secondary winding 6 and, consequently, with the energy at the plug. Switch device 5 comprises a Darlington transistor 11 with the collector connected to one terminal of primary winding 4, the emitter connected to the reference ground, and the base connected to the collector via a Zener diode 12. The base of transistor 11 is driven by an electric block 13, the functions of which are described later on, and which, together with switch device 5, constitutes an ignition module 14.

The collector voltage of transistor 11 is known to be close to zero only when the transistor is saturated, and to be equal to or greater than voltage V1ref when transistor 11 is off. High voltage is generated in secondary winding 6 upon the base control current of transistor 11 being cut off for disabling the emitter-collector circuit, at which point the collector voltage reaches the maximum value limited by diode 12. Subsequently, the collector voltage reflects the high voltage at the terminals of secondary winding 6, with hold values of a few tens of volts throughout the duration of the arc between the plug electrodes.

As shown in Fig.1, device 1 comprises an electric block 15 defined by an operational amplifier (functioning as a comparator) having two inputs connected to respective terminals of primary winding 4, for determining the difference between the collector voltage and reference voltage V1ref. Block 15 generates a positive output signal when the collector voltage is sufficiently higher than reference voltage V1ref, which situation persists as long as high voltage is present at the terminals of secondary winding 6. In other words, block 15 generates a positive pulse, the duration of which is closely related to that of the electric arc between the plug electrodes.

Device 1 also comprises an electric block 16 having an integrating block 17, a signal hold block 18, and an electronic switch 21 for connecting and disconnecting blocks 17 and 18. Block 17 presents two inputs, one connected to the output of block 15 and the other to reference voltage V2ref, and an output connected to the common terminal 22 of switch 21. The output pulse from block 15 drives block 17, which provides for proportionally converting the duration of the pulse into a voltage signal. A capacitor 23 with an analog storage function is provided parallel to and between the output and pulse input of block 17. The pulse input of block 17 is also connected to terminal 24 of switch 21. In Fig.1, block 17 is shown in the initialization state.

As connection and disconnection of blocks 17 and 18, i.e. control of switch 21, must be synchronized with the collector voltage, device 1 comprises an actuator block 25 which, depending on analysis of the collector voltage, generates a signal for controlling switch 21. During the primary winding charge phase, i.e. with transistor 11 saturated, block 18 is isolated from block 17, during which time, as shown clearly in Fig.1, block 17 is initialized by virtue of capacitor 23 being shortcircuited and discharged. Upon the collector voltage exceeding reference voltage V5ref, actuator block 25 triggers switch 21 so as to disconnect terminals 22 and 24 and connect terminal 22 to a terminal 26 connected to one input of block 18. Alternatively, switch 21 may be controlled by block 25 in the presence of the base control current of transistor 11.

Block 18 presents a first input connected both to terminal 26 of switch 21 and, via a capacitor 27, to a reference ground; an output connected to electric block 28; and a second input connected to its own output. When isolated, block 18 saves the integration valu received from block 17 during the previous connection, so that, at the end of the electric arc, the output of block 16, and more

specifically the output of block 18, supplies an analog quantity proportional to the duration of the arc. Block 28 acts as an output interface for the analog signal generated by block 16, and, consisting substantially of an amplifier, provides, on the basis of reference voltage V3ref, for amplifying and so achieving an appropriate volume range of the analog signal. Block 28 presents an output connected both to an electronic control system 31 and to an electric comparing block 32 in turn connected to system 31. On the basis of reference voltage V4ref, block 32 constantly controls the integration value, so as to inform system 31 of the absence or insufficient duration of the spark. On the basis of this information, system 31 diagnoses the spark and, in the event of a defect, informs the user via alarm 33, which may consist singly of a sound alarm, alarm light or display, or a combination of all three.

The spark defect may be caused by spark failure, severe wear of the spark plug, too wide a gap between the plug electrodes, fuel pressure peaks inside the cylinder, or by failure or wear of one or more components of system 2. In the event block 7 presents a distributor, system 31 may also be supplied with information detected by engine speed and stroke sensors, thus enabling it to correlate the incoming signals from blocks 28 and 32 to a specific spark plug.

System 31 is also supplied with a number of electric signals relative to operation of the component parts and all the chemical-physical parameters of the engine, and which enable it to determine the operating speed of the engine. On the basis of the signal received from block 28, system 31 determines the energy available at the spark plug, and, on the basis of a map stored in an internal memory block and containing optimum energy values in relation to engine speed, compares the available energy value with the optimum value for the engine speed in question. The outcome of the comparison gives rise to a signal, which is fed back to ignition module 14 for automatically controlling the charge of primary winding 4 and so automatically controlling the energy to be supplied to the plug for the next spark following the one whose duration has been detected. Block 13 then activates switch device 5.

In addition to the gap between the plug electrodes and the energy available at the plug, the spark also depends on the physical-chemical condition of the air-fuel mixture, which constitutes the dielectric between the electrodes. In other words, the spark also dep nds on the strength, pressure and temperature of the mixture. Any variation in the physical-chemical condition of the mixture, such as high pressure peaks in the cylinder, may be compensated by system 31 increasing the energy to be made available at the plug. For a given physical-chemical condition of the mixture, on the other hand, system 31 provides for controlling any deviation between the optimum and detected energy values. By comparing said deviation with a given threshold value, system 31 is able to determine whether the duration of the arc is restored automatically to the optimum value by increasing the energy made available to the plug. In the event of a negative response, i.e. despite increased energy supply to the plug, the duration of the spark fails to be restored to the optimum value, system 31 diagnoses faulty operation of ignition system 2, due to wear of the plug, fouling of the electrodes, impaired system components, broken cables, etc. System 31 may be provided with means for storing the spark duration signals for considerable periods of time, and so processing statistical data relative to the signal values, for enabling more accurate diagnosis of long-term operation of ignition system 2 and its components.

Number 41 in Fig.2 indicates an ignition control device for an internal combustion engine electronic ignition system 2 featuring a coil 3, or rather a secondary winding 6, for each spark plug, which, in this case also, is shown schematically by block 7. In view of the similarity between the circuit diagrams of devices 41 and 1, similar components are indicated using the same numbering system. Device 41 differs substantially from device 1 in that it provides for detecting the energy available at the plug, or rather a specular image, as opposed to the duration of the arc from which to deduce said energy. As compared with device 1, device 41 thus provides for more accurately controlling switch device 5 and, consequently, the energy supplied to the plug. A further characteristic of device 41 is that it provides for detecting additional quantities, thus enabling more accurate diagnosis.

Device 41 detects current I2pk and voltage Vm2, and provides for integrating the product of the two. For this purpose, device 41 comprises an electric block 42 input-connected to the terminal of primary winding 4 connected via device 5 to the reference ground, which block 42 provides for attenuating and filtering the input quantity, and as such may consist of a straightforward voltage divider. The input quantity consists of the collector voltage, which, as stated, reflects the plug voltage, so that the output quantity of block 42 is an image of voltage Vm2.

Device 41 also comprises an amplifying block 43, the input of which is connected to the terminal of secondary winding 6 connected to the reference ground. Block 43 is supplied with a quantity which is an image of current I2pk, this current being detected as the voltage drop over a resistor 44 of known value connected between secondary wind-

ing 6 and the reference ground. The outputs of blocks 42 and 43 are connected to an analog multiplying block 45, which provides for multiplying the input quantities, while at the same time taking into account the constants inherent in blocks 42 and 43, and which supplies an output quantity which is an image of the energy available at the plug. The signal relative to said quantity is then processed in the same way as the spark duration signal of device 1, for which purpose, block 45 is connected to a block 16, the switch 21 of which is controlled by blocks 25, 28 and 32. As the quantity involved in the case of device 41 differs from that processed by the same blocks 16, 25, 28 and 32 of device 1, the reference voltages of said blocks, though indicated in the same way in Fig.2, may obviously differ as compared with those of device 1.

The output of block 43 is connected to a block 46 substantially defined by an operational amplifier, which compares the input signal with a reference voltage V6ref, and the difference signal at the output of which is processed in the same way as described above by a further block 16 with a block 25, and by further blocks 28 and 32. What was said previously relative to a possible difference in reference voltage also applies to these blocks. Device 41 may, of course, present one block 25 for simultaneously controlling switches 21 of both blocks 16. Control system 31 is thus supplied with signals relative to both the energy available at the plug and current I2pk of secondary winding 6, and, as in the case of device 1, on the basis of the spark duration and plug energy signal, controls module 14 for automatically controlling the charge of primary winding 4 and, consequently, the energy to be supplied to the plug for the next spark following that to which the signal applies. On the basis of all the incoming signals, system 31 also provides for diagnosing system 2 and its components.

The advantages of the present invention will be clear from the foregoing description.

In particular, the device according to the present invention provides for supplying signals updated as of the previous cycle, so as to automatically control energy supply to the plug as a function of engine demand in the foregoing cycle, thus enabling energy saving, by virtue of the average spark energy requirement of the engine undoubtedly being less than the maximum value supplied at all times by currently used ignition systems. As such, the ignition system components (plugs, coil, electronic components, etc.) may be sized to operate as a function of the mean, as opposed to maximum, spark energy value. What is more, reducing the mean current in the secondary winding of the coil provides for extending the working life of the plug. In other words, the device according to the present invention provides for reducing both the running and production cost of the ignition system. The device according to the present invention also provides for further advantages in terms of operation and long-term protection of catalytic mufflers, by automatically compensating for wear of the spark plugs, which otherwise results in increased energy demand for the spark. What is more, by establishing minimum and maximum energy thresholds in the control system for each engine speed, it is possible, not only to diagnose operation and the condition of the ignition system and components, but also to provide for long-term protection of the catalytic muffler and ignition system by informing the user whenever said thresholds are exceeded.

To those skilled in the art it will be clear that changes may be made to devices 1 and 41 as described and illustrated herein without, however, departing from the scope of the present invention.

In particular, the component blocks of devices 1 and 41 may be fully or partially integrated in control system 31, so that the functions of said blocks may be performed by programs inside control system 31.

Claims

1. An ignition control device for an internal combustion engine electronic ignition system (2); said system (2) comprising a coil (3), the primary winding (4) of which presents a first terminal connected to a first reference voltage (V1ref), and a second terminal connected to a reference ground via a switch device (5), and the secondary winding (6) of which supplies an ignition block (7); characterized by the fact that it comprises:

   means, which, for the spark of each operating cycle of said ignition block (7), provides for detecting first signals relative to the energy available between the electrodes of said ignition block (7);

   means (31, 16) for processing said first signals and computing a quantity representing the energy available between the electrodes of said ignition block (7);

   means (31) for computing the speed of said engine as a function of a number of second signals;

   means (31) for comparing said quantity with values considered optimum for each speed of said engine and stored in an internal memory block; and

   means (31, 13) for controlling the charge of said primary winding (4) via a third signal resulting from said comparison, and for driving said switch devic (5), so as to automatically

control the energy to be made available between the electrodes of said ignition block (7) for the spark of th cycle following that in which said first signals are detected.

2. A device as claimed in Claim 1, characterized by the fact that it comprises:
   means (31) for comparing said quantity representing the energy available between the electrodes of said ignition block (7) with predetermined values for each speed of said engine, memorized in said internal memory block, and respectively relative to a maximum and minimum threshold; and
   means (33), consisting singly or of a combination of a sound alarm, alarm light and display, for indicating crossover of said threshold values.

3. A device as claimed in at least one of the foregoing Claims, characterized by the fact that said processing means comprise:
   a first electric integrating block (17) for proportionally converting the duration of said first signal into a voltage signal;
   a second electric signal-maintaining block (18) for saving the integration value received from said first integrating block (17);
   a third electric block (21) for electrically connecting and disconnecting said first integrating block (17) and said second signal-maintaining block (18); and
   a fourth block (23) for initializing said first integrating block (17) at each operating cycle of said ignition block (7).

4. A device as claimed in Claim 3, characterized by the fact that it comprises means (25) for controlling said third connecting and disconnecting block (21) synchronously with control of said switch device (5).

5. A device as claimed in Claim 3 and/or 4, characterized by the fact that it comprises a fifth electric block (32) for controlling the integration value, on the basis of a second reference voltage (V4ref), and so determining the absence or insufficient duration of the spark.

6. A device as claimed in at least one of the foregoing Claims from 3 to 5, characterized by the fact that said detecting means comprise, connected to said processing means (16), a sixth electric block (15) for detecting, as said first signal, th voltage at the terminals of said primary winding (4), and for generating a positive pulse whenever the electric potential at the second terminal of said primary winding (4) is sufficiently greater than said first reference voltage (V1ref), and for so generating a positive pulse the duration of which is closely related to the duration of the electric arc between the electrodes of said ignition block (7).

7. A device as claimed in at least one of the foregoing Claims from 3 to 5, characterized by the fact that said detecting means comprise, connected to said processing means (16), a seventh electric block (45) receiving, as said first signals, the electric potential at the second terminal of said primary winding (4) and reflecting the voltage between the electrodes of said ignition block (7), and a quantity which is an image of the current along said secondary winding (6) the current being detected as the voltage drop over a resistor (44) of known value; said seventh block (45) preferably consisting of an analog multiplier for multiplying the incoming quantities and so obtaining a signal relative to a quantity which is an image of the energy available between the electrodes of said ignition block (7).

8. A device as claimed in Claim 7, characterized by the fact that said detecting means comprise an eighth electric block (46) for comparing the image quantity of the current along said secondary winding (6) with a third reference voltage (V6ref); and by the fact that it comprises further means (16), provided with said control means (25), for processing the output signal from said eighth block (46).

9. A device as claimed in any one of the foregoing Claims, characterized by the fact that it comprises an electronic control system (31) having internal operating blocks consisting of said processing means, said computing means, said comparing means, and said control means.

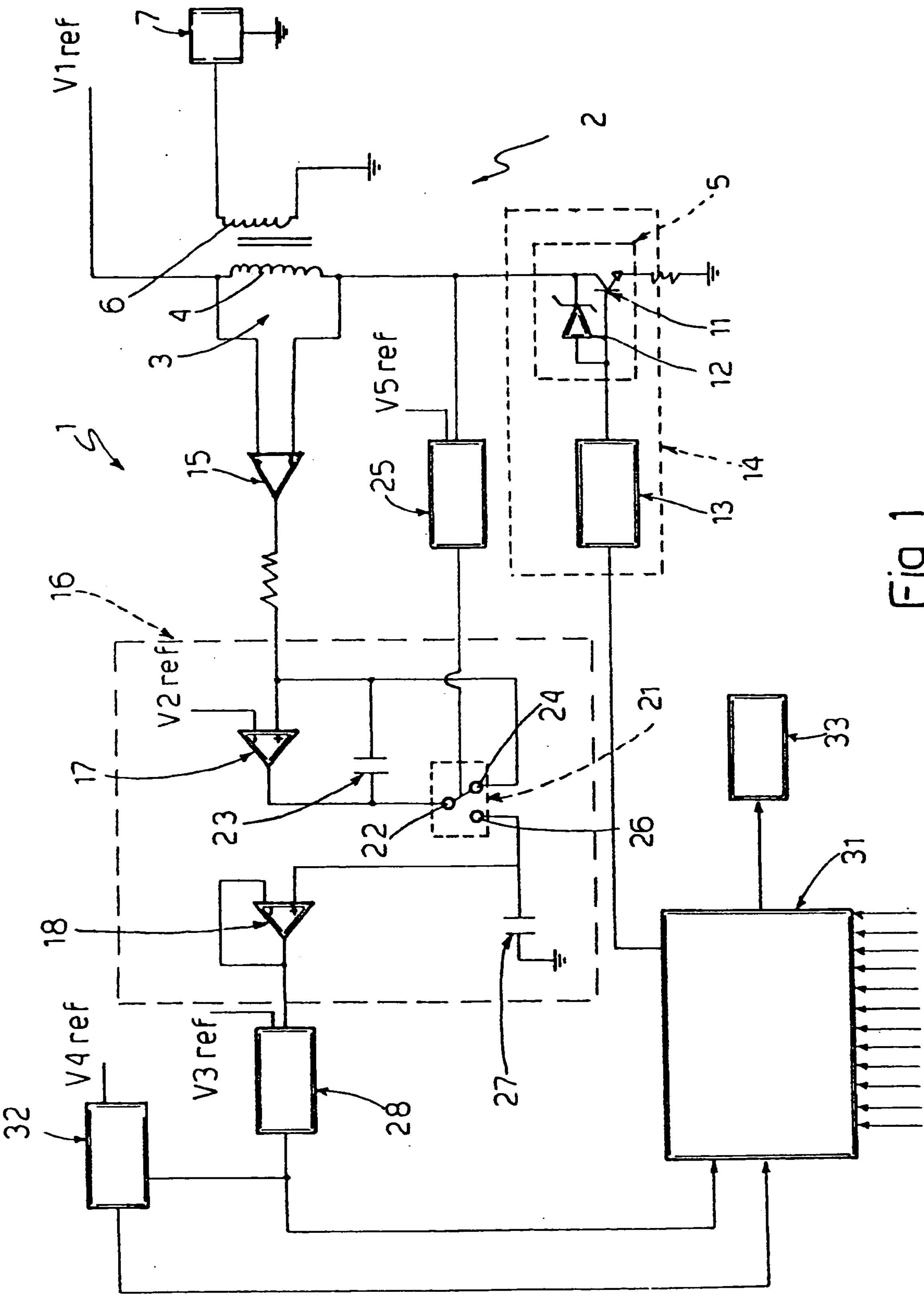
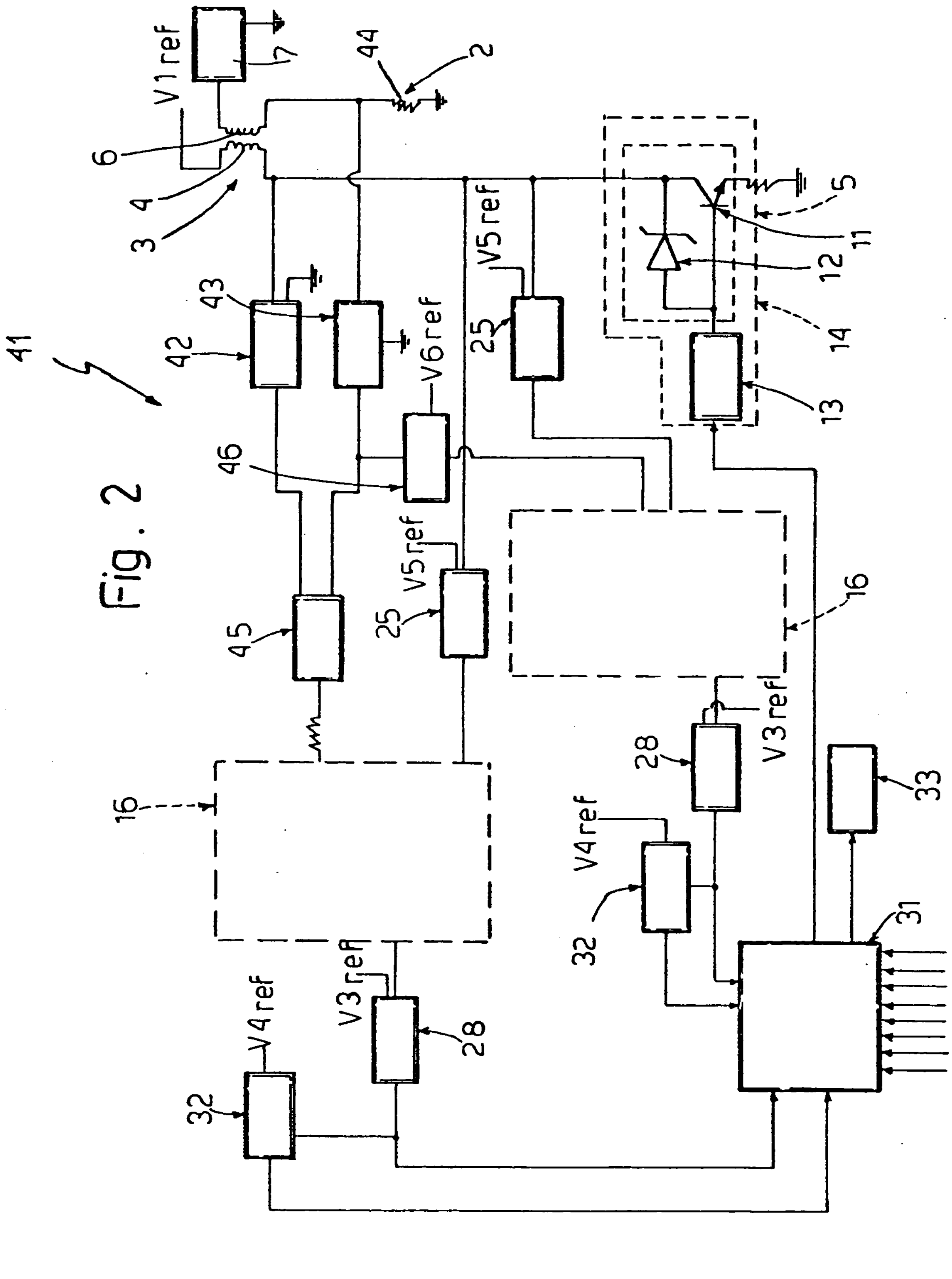

V1ref
7
2
6
4
3
5
11
12
1
15
V5ref
25
13
14
16
V2ref
24
21
17
23
22
26
18
31
33
V4ref
V3ref
32
28
27

Fig. 1



41
V1ref
7
44
2
6
4
3
43
42
V6ref
46
V5ref
25
11
12
5
14
13
16
45
V3ref
28
V4ref
32
33
31

Fig. 2

(19) Eur päisches Patentamt
European Patent Office
Office eur péen des brevets

(11) Publication number: **0 555 851 A3**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **93102158.8**

(22) Date of filing: **11.02.93**

(51) Int. Cl.5: **F02P 3/04**, F02P 3/045, F02P 3/05, F02P 17/00

(30) Priority: **13.02.92 IT BO920049**

(43) Date of publication of application: **18.08.93 Bulletin 93/33**

(84) Designated Contracting States: **DE ES FR GB**

(88) Date of deferred publication of the search report: **06.07.94 Bulletin 94/27**

(71) Applicant: **WEBER S.r.l.**
Corso Marconi, 20
I-10125 Torino(IT)

(72) Inventor: **Rossi, Daniele**
Via Vicenza, 1/1
40050 Monte S. Pietro(IT)
Inventor: **Facciolo, Fabio**
Via Filippo Turati, 23
40012 Calderara di Reno(IT)

(74) Representative: **Jorio, Paolo et al**
Studio Torta,
Via Viotti, 9
I-10121 Torino (IT)

(54) Ignition control device for an internal combustion engine electronic ignition system.

(57) A device for controlling an electronic engine ignition system (2) comprising a coil (3), the primary winding (4) of which is connected between a reference voltage and ground via a switch block (5), and the secondary winding (6) of which is connected between the electrode of a spark plug (7) and ground. The device comprises means for detecting, for the spark of each operating cycle, signals relative to the energy at the spark plug; means for computing engine speed; means for comparing the energy of the plug with optimum values for each engine speed; and means for controlling charging of the primary winding via a signal resulting from the above comparison, and for driving the switch block, so as to control energy supply to the plug for the spark of the next cycle. Further, the detected spark signals are used to diagnose the ignition system and an user is informed by indicating means of a fault condition.

EP 0 555 851 A3

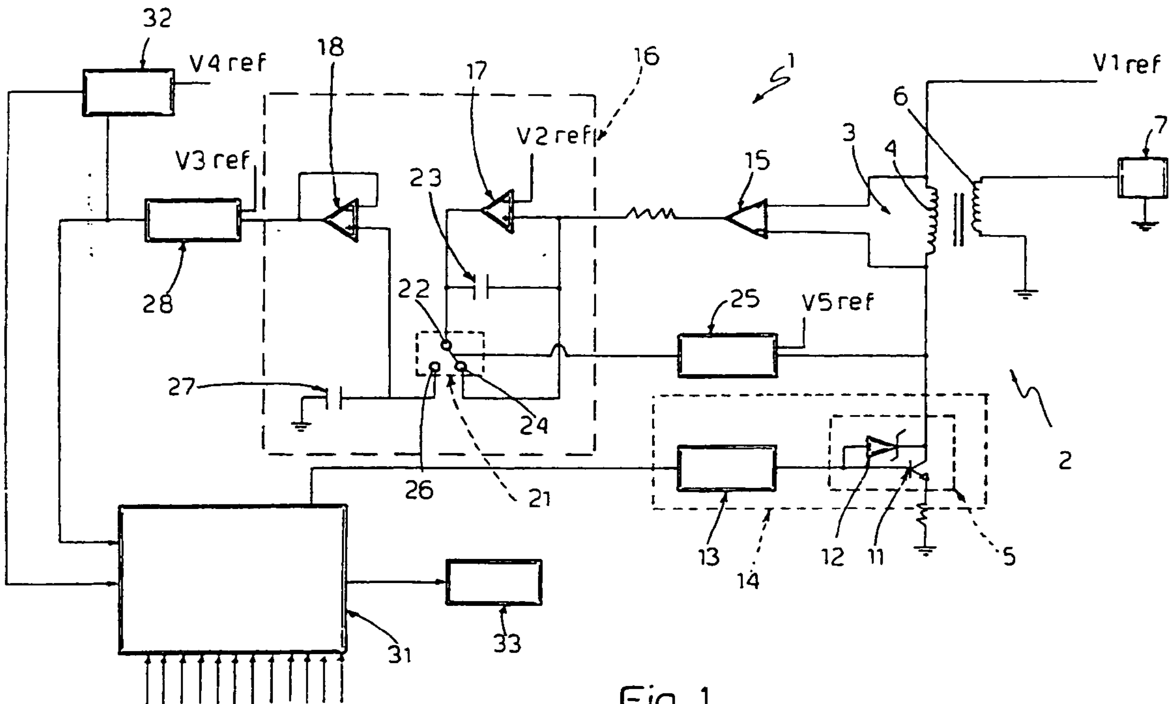

32
V4 ref
18
17
16
1
V1 ref
6
7
V2 ref
V3 ref
23
15
3
4
28
22
25
V5 ref
27
24
2
26
21
13
12
11
5
14
31
33

Fig.1

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 10 2158

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X Y	US-A-5 054 461 (DEUTSCH ET AL) * abstract; claims; figures * ---	1,2,9 3-8	F02P3/04 F02P3/045 F02P3/05 F02P17/00
Y A	US-A-4 380 989 (TAKAKI) * the whole document * ---	3-8 1	
A	EP-A-0 281 528 (MARELLI AUTRONICA S.P.A.) * column 4, line 25 - line 53; figures * ---	1	
A	DE-A-27 59 154 (ROBERT BOSCH GMBH) * the whole document * -----	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
			F02P

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	9 May 1994	Michels, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document